IIAX studies of liquid metal erosion

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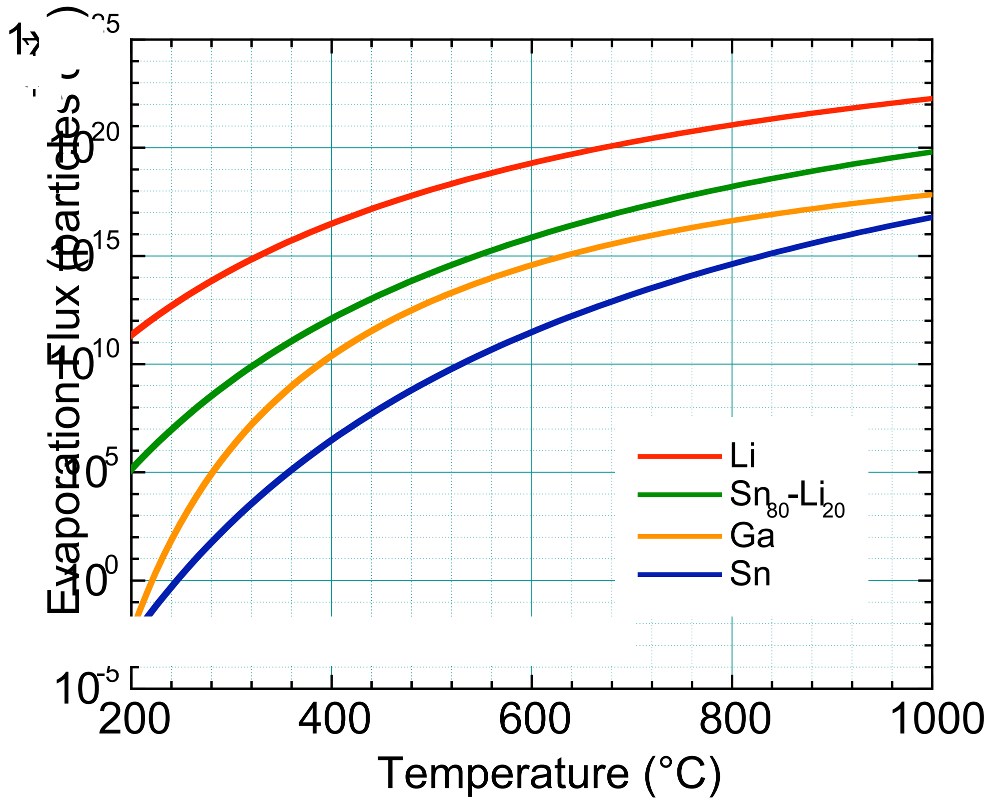
Outline

- The advantage of Sn
- Ion-surface InterAction eXperiment (IIAX)
- Experimental Plan
- Sputtering trends with varying temperature
  - Light ion bombardment
  - Heavy ion bombardment
- Summary
- Future Work

Advantage of using liquid Sn

- Sn has an evaporative flux many orders of magnitude lower than Li
- Friendly & abundant
- Evaporation curves based on theory by [2] and fits from [3] and [4].



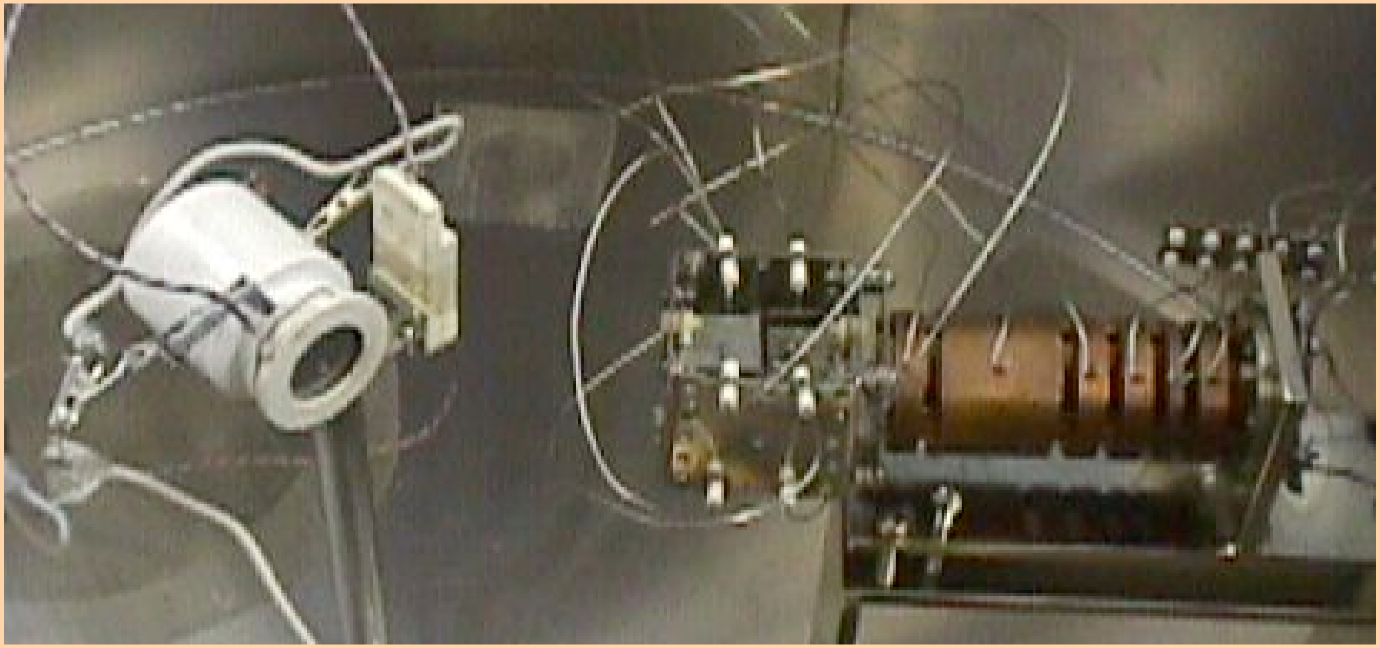
[1] R. Bastasz and J. Whaley, *Analysis of Liquid Tin Surfaces*, APEX/ALPS Meeting, PPPL, Nov. 4-8, 2002.

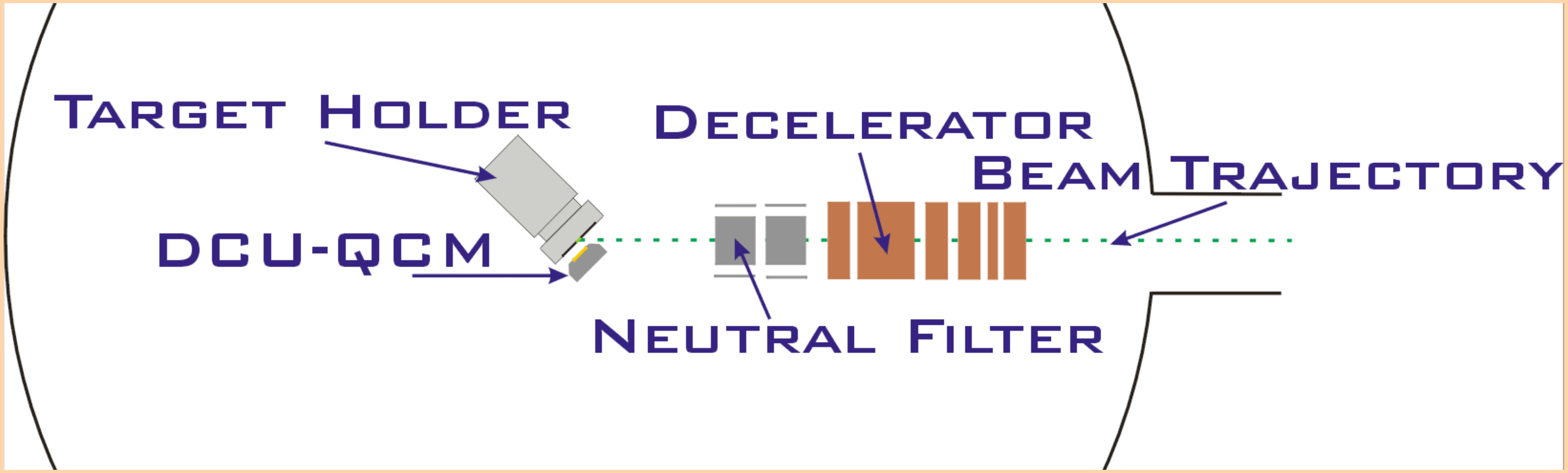
[2] Y. Waseda, S. Ueno, K.T. Jacob, J. Mat. Sci. Let, 8, (1989) 857-861.

[3] M.A. Abdou, A. Ying, N.B. Morley et al., APEX Interim Report Report No. UCLA-ENG-99-206, (1999).

[4] I.A. Sheka, I.S. Chaus, T.T. Mityureva, *The Chemistry of Gallium*, (1966), Elsevier, Amsterdam.

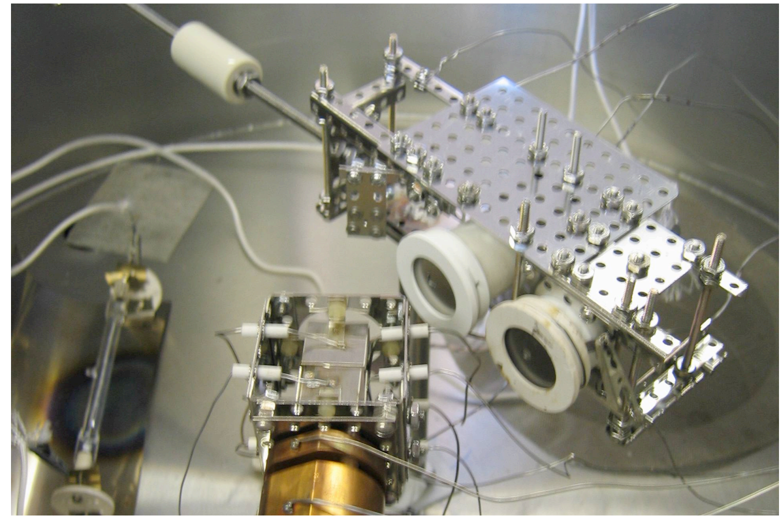
IIAX:
Sample Chamber

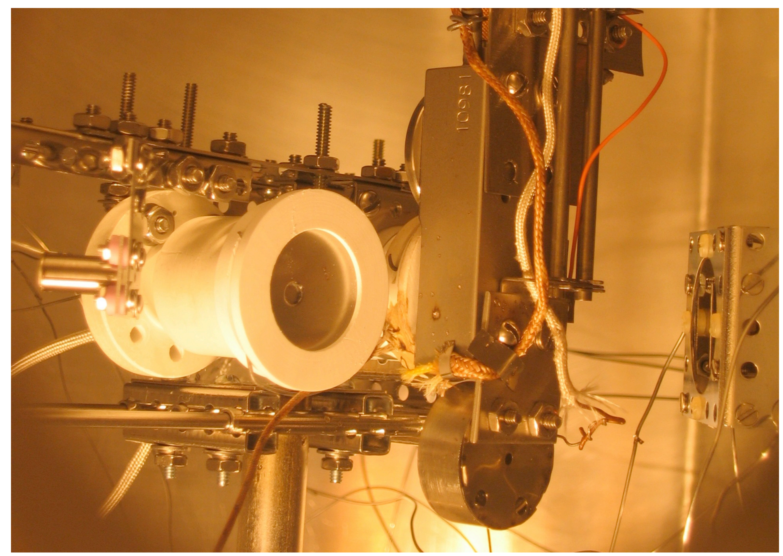




Minor modifications in IIAX

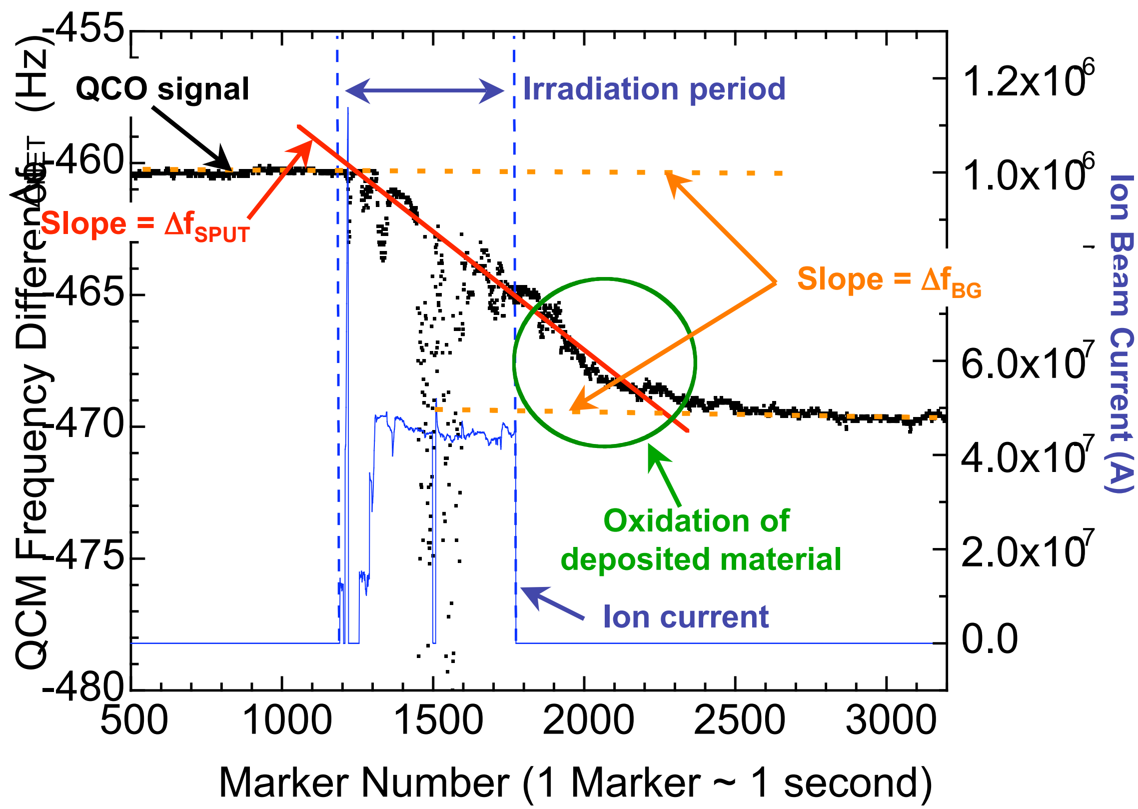
- Single target replaced with target carriage to better diagnose beam profile
- Allows precise determination of the fraction of the ion beam that bombards the target (instead of measuring the sum of the current on the target and that on the evaporation shield)
- There wasn't a need for this previously as the beam was well-diagnosed; increased diagnostic ability was required due to changes in the system





Determination of deposited mass via QCO frequency and beam current vs. time plot

- Before liquid target is irradiated with ion beam, a background flux measurement is completed
- QCM frequency difference slope increases when beam hits target measuring the sputtering flux
- When beam is off, some oxidation follows until original background flux is obtained



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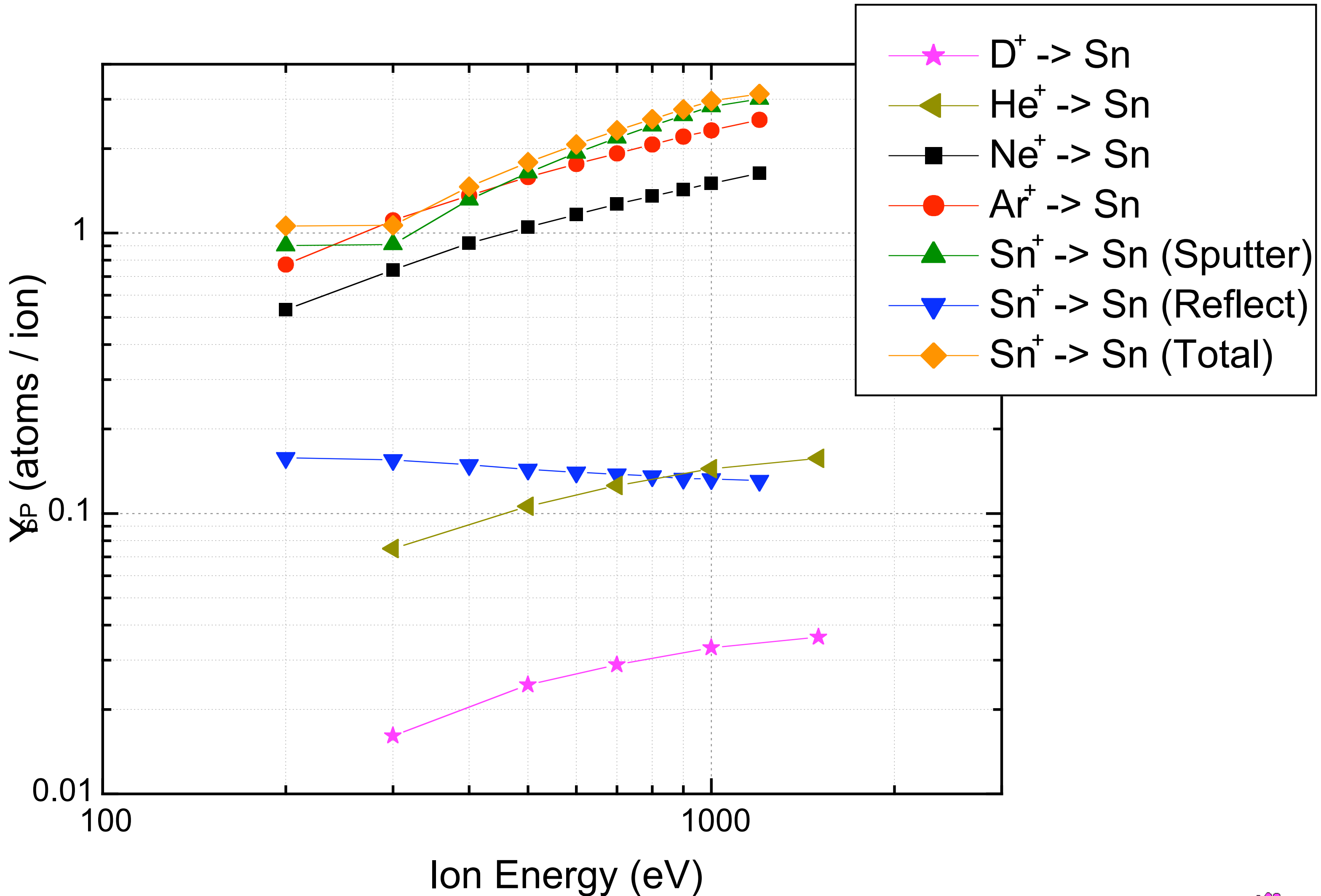
Overview of IIAX Sn experiments

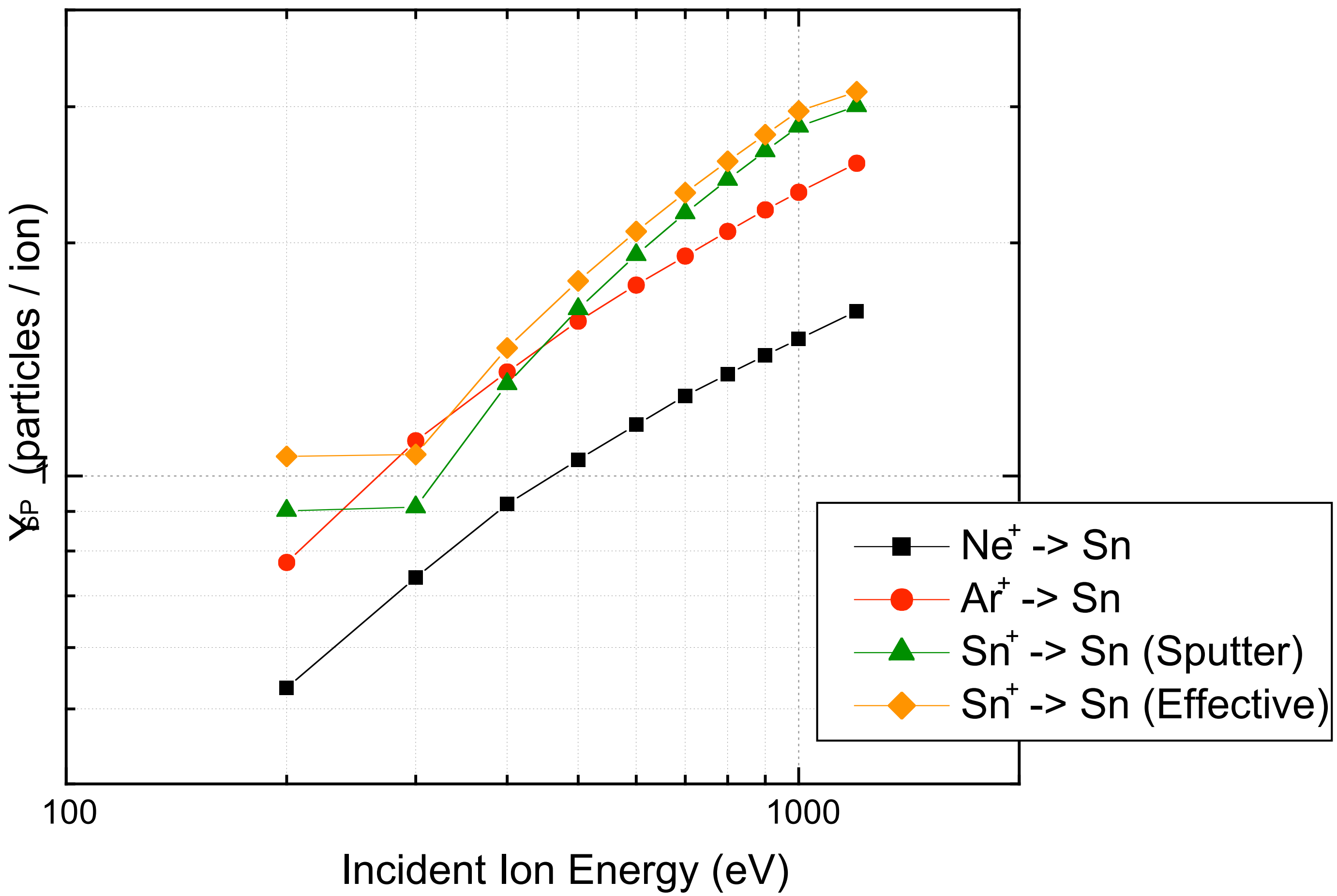
- Previous experiments:
  - Y_{SP} of D^+ _ Sn (s, l)
  - Y_{SP} of He^+ _ Sn (s, l)
- Goals of current series of experiments:
  - Y_{SP} of Ar^+ _ Sn (s, l)……in progress.
  - Y_{SP} of Sn^+ _ Sn (s, l)……coming up.
- Via results of above experiments…
  - We hope to better understand any mass-dependence of the enhancement of the sputtering yield
  - Sn self-sputtering measurements are helpful for future modeling efforts

VFTRIM Simulation Results



VFTRIM Simulation Results

Heavy Ion Bombardment of Solid Sn



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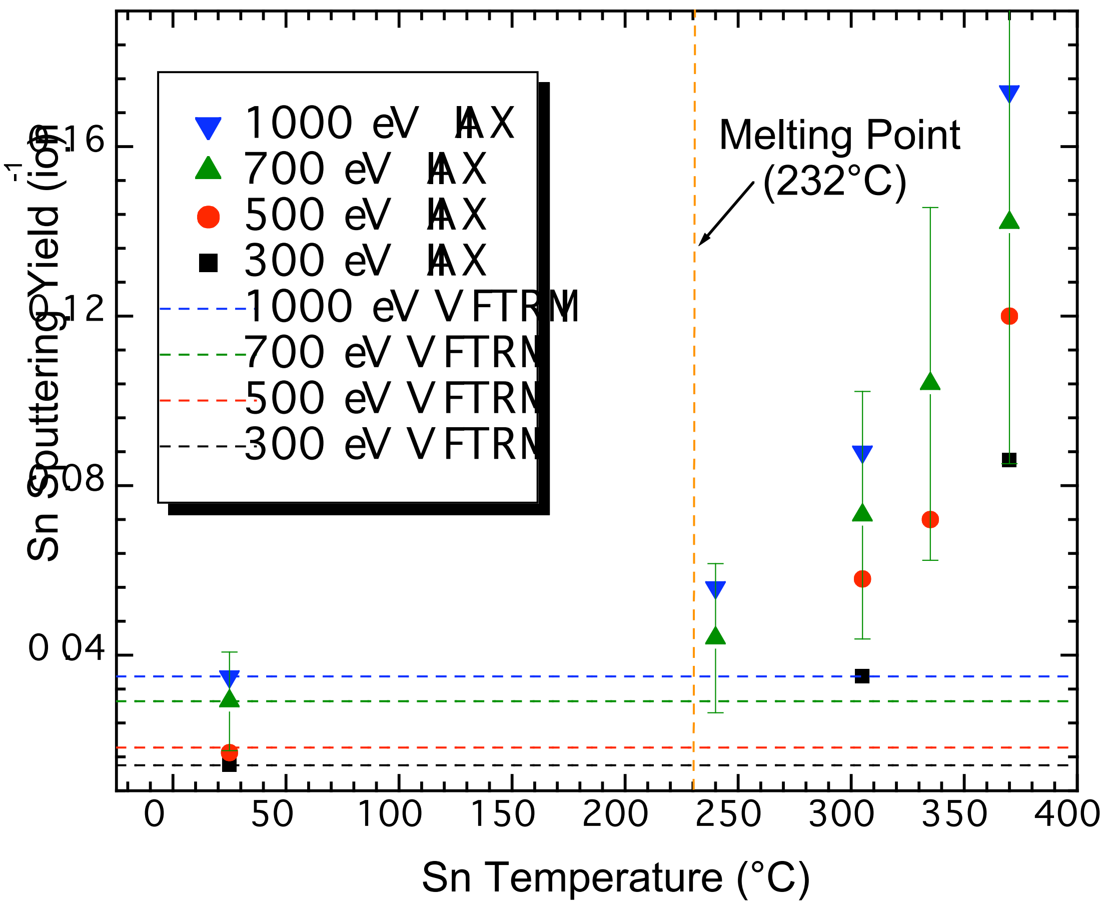
Sn sputtering yield vs. sample temperature for D^+ irradiation

$D^+ \rightarrow Sn$

- Mass ratio:
  $m_2/m_1 = 59$
- e-folding temperature for 1000 eV at 300°C
- Slight change at phase change but most enhancement at higher temperatures (> 300°C)



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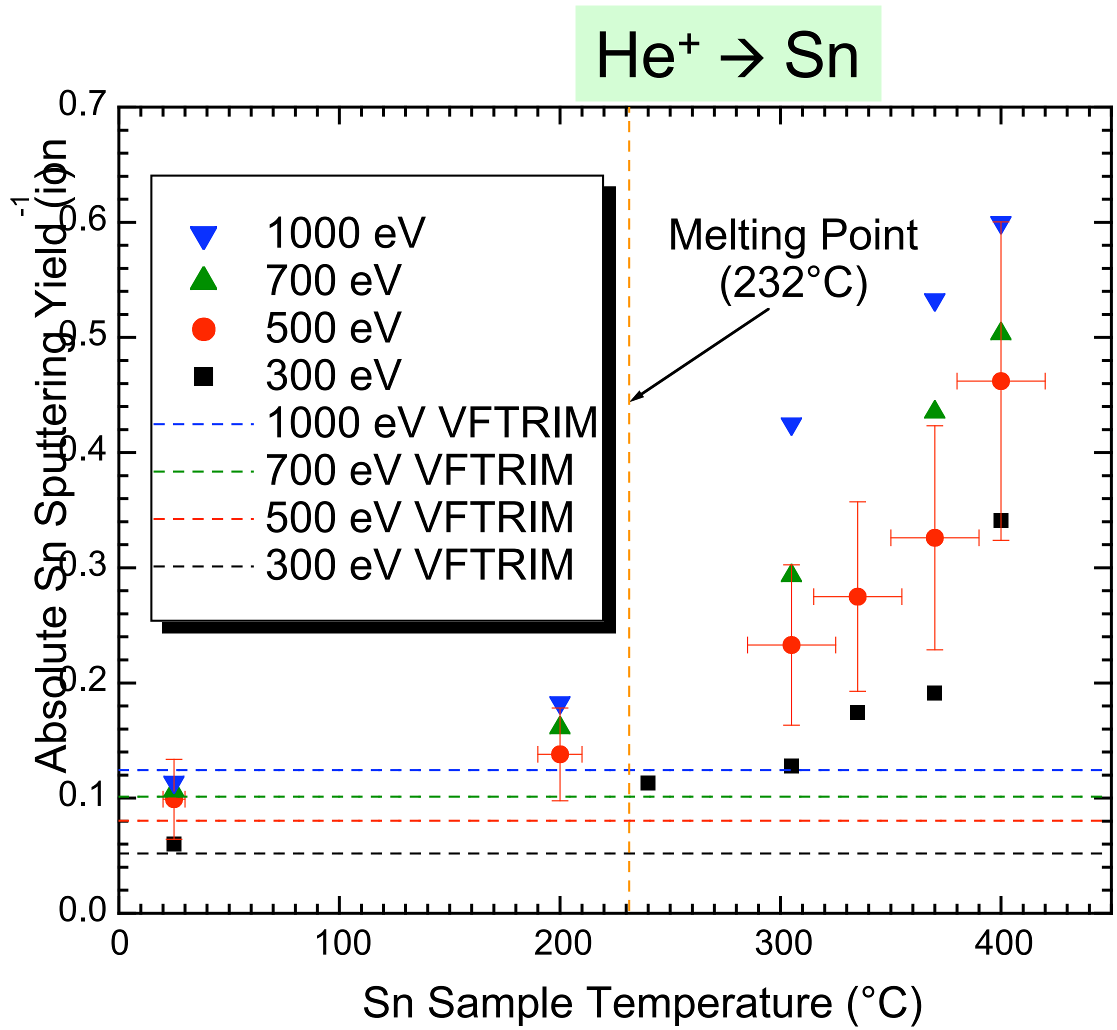
Sn sputtering yield vs. sample temperature during He^+ irradiation

- Mass ratio: $m_2/m_1 = 30$
- E-folding temperature > T_m & < 300°C
- Less steep of an incline, but with greater magnitude of enhancement



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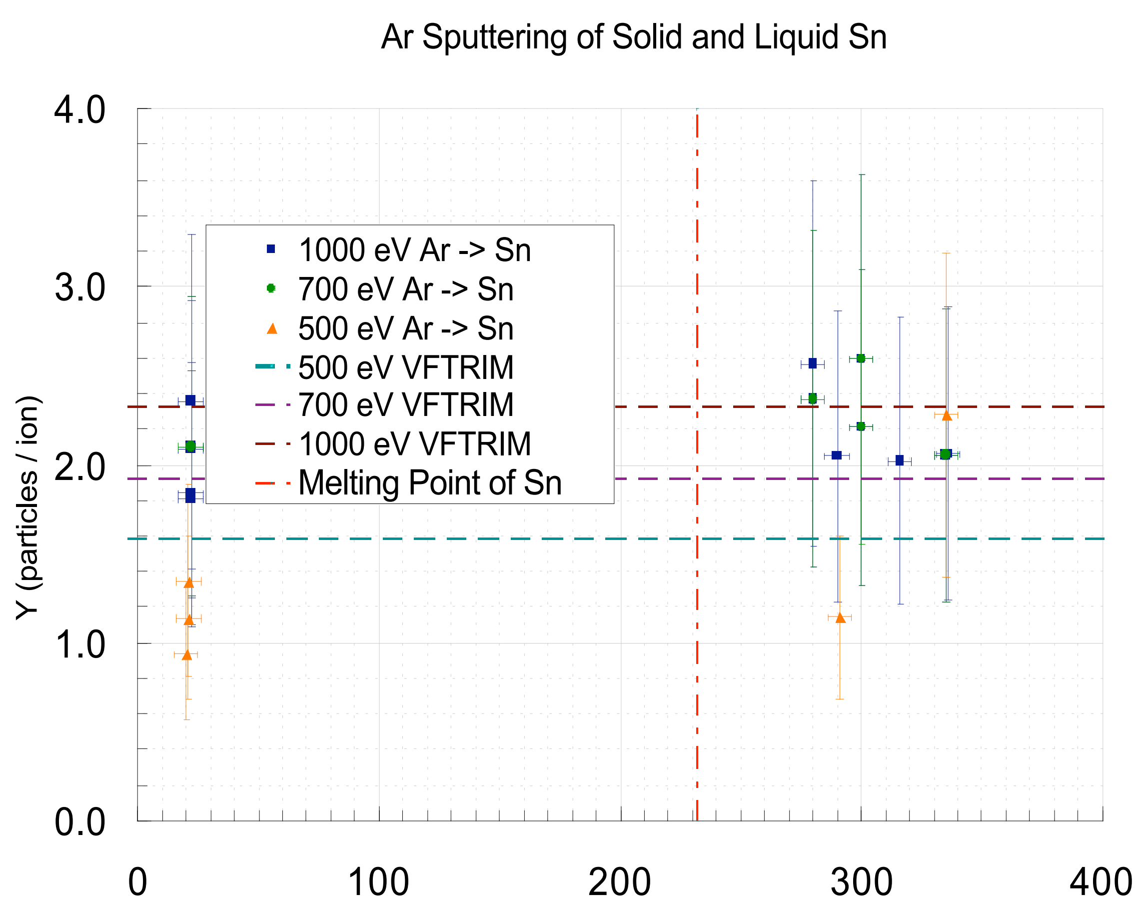
Heavy ion bombardment of Sn: Ar on solid and liquid Sn

- Mass ratio:
  $m_2/m_1 = 3.0$
- Little or no temperature enhancement seen *at this range of temperatures*
- Why do we see enhancement for light ion bombardment at these temps but not for heavy ions?



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Summary

- Argon sputtering of tin doesn't seem to show temperature enhancement in the ion and temperature range considered (500-1000 eV and sample temperatures < 340°C)
- This compares to drastic increases in the sputtering yield for light ions (D^+ & He^+) from room temperature to 340°C
- Need even higher-temperature Ar^+ runs (not possible at this time) and possibly Ne^+ runs to fill in the gap in the mass ratio
- It will be interesting to see how the tin self-sputtering will perform with sample temperature

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Future Work

- Near Term (this month):
  - Attempt higher temperatures with Ar^+ on liquid Sn (depends on hardware limitations / mood)
  - Perform Sn^+ on liquid Sn at a range of temperatures (20 < T < 400°C) & energies (500 < E_0 < 1000 eV)
- Longer Term (fall 04 – spring 05):
  - Y_{SP} Mixed materials (C/W, Be/W, W/C etc.)
  - Fraction of sputtered material in charged state
  - Effects of impurities on the ion fraction yield of lithium (does this change the 2/3 number?)
  - ***Modeling…***
- *Possibly* squeeze in higher temperature modifications to allow sample temperatures > 400°C.

Acknowledgements

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